Scoping MEMS seismometers for deployment on the Moon

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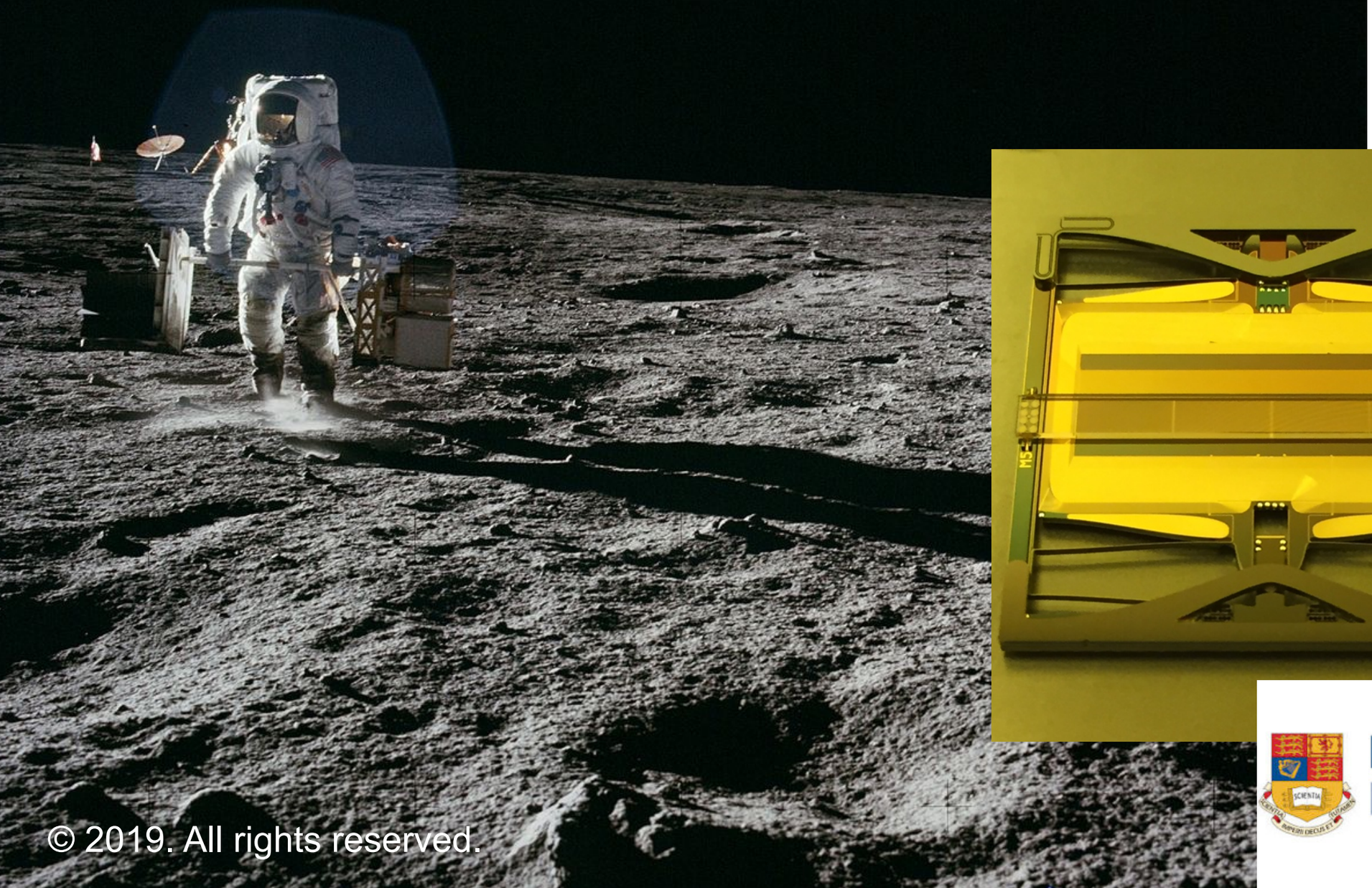
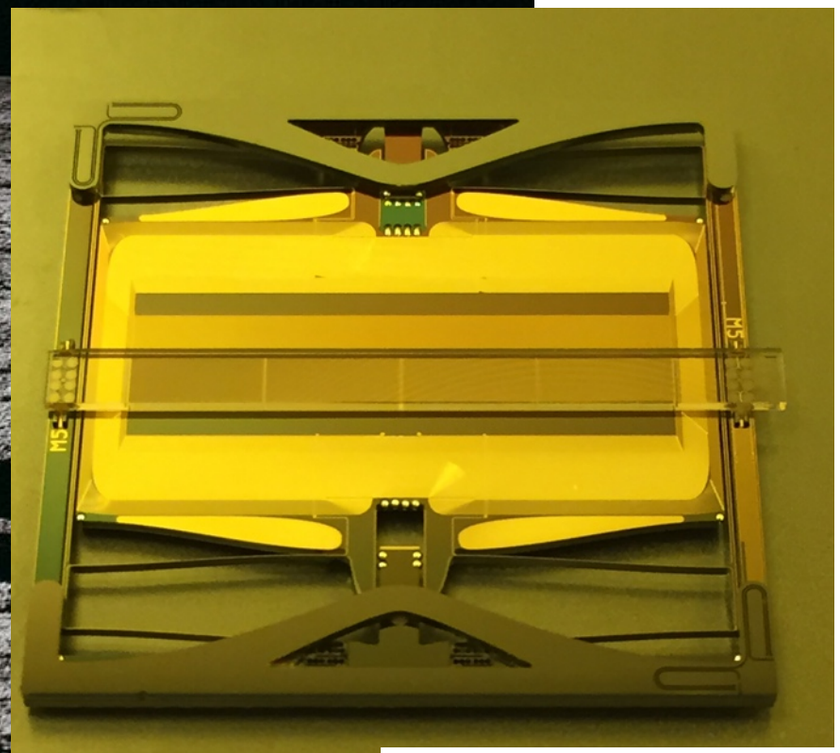
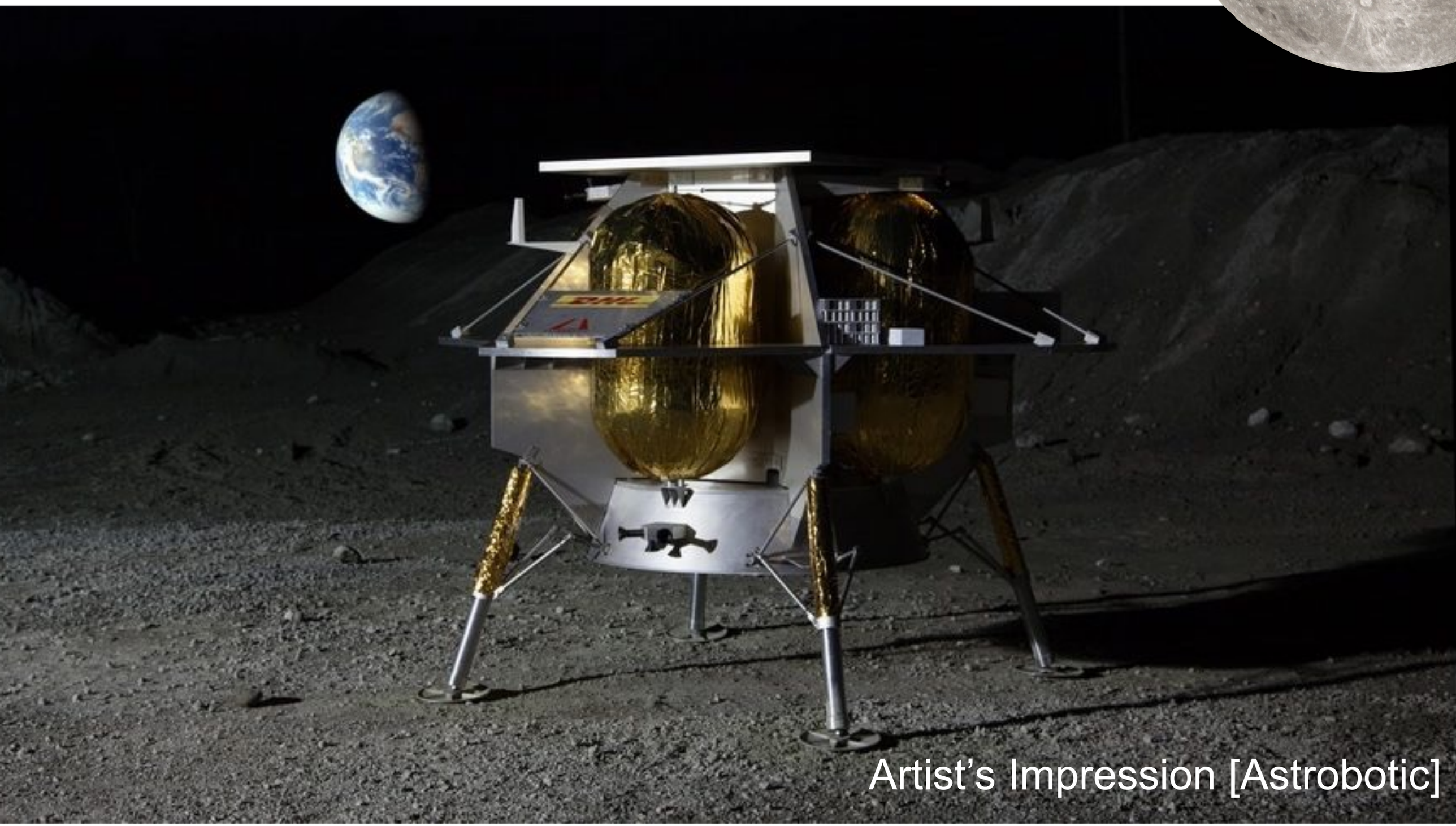




Commercial Lunar Payload Services (CLPS)



Artist’s Impression [Astrobotic]

Commercial Lunar Payload Services (CLPS)

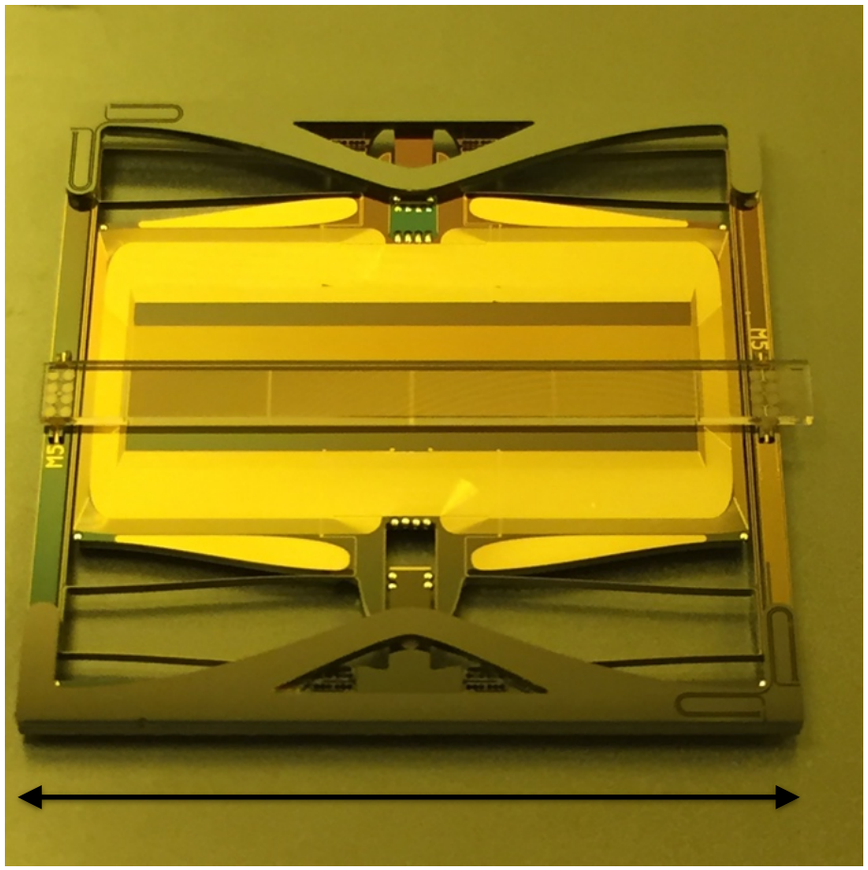
Artist’s Impression, MX-1E Lander [MoonExpress]

Commercial Lunar Payload Services (CLPS)

9 scientific payloads selected by NASA in February 2019:

- Information about Entry, Descent and Landing (to support future human spaceflight)
- Magnetometer
- The Ion-Trap Mass Spectrometer for Lunar Surface Volatiles instrument
- The Linear Energy Transfer Spectrometer
- Low-frequency Radio Observations from the Near Side Lunar Surface
- Stereo Cameras for Lunar Plume-Surface Studies
- Surface and Exosphere Alterations
- Navigation Doppler Lidar for Precise Velocity and Range Sensing
- Resource Prospecting Instruments

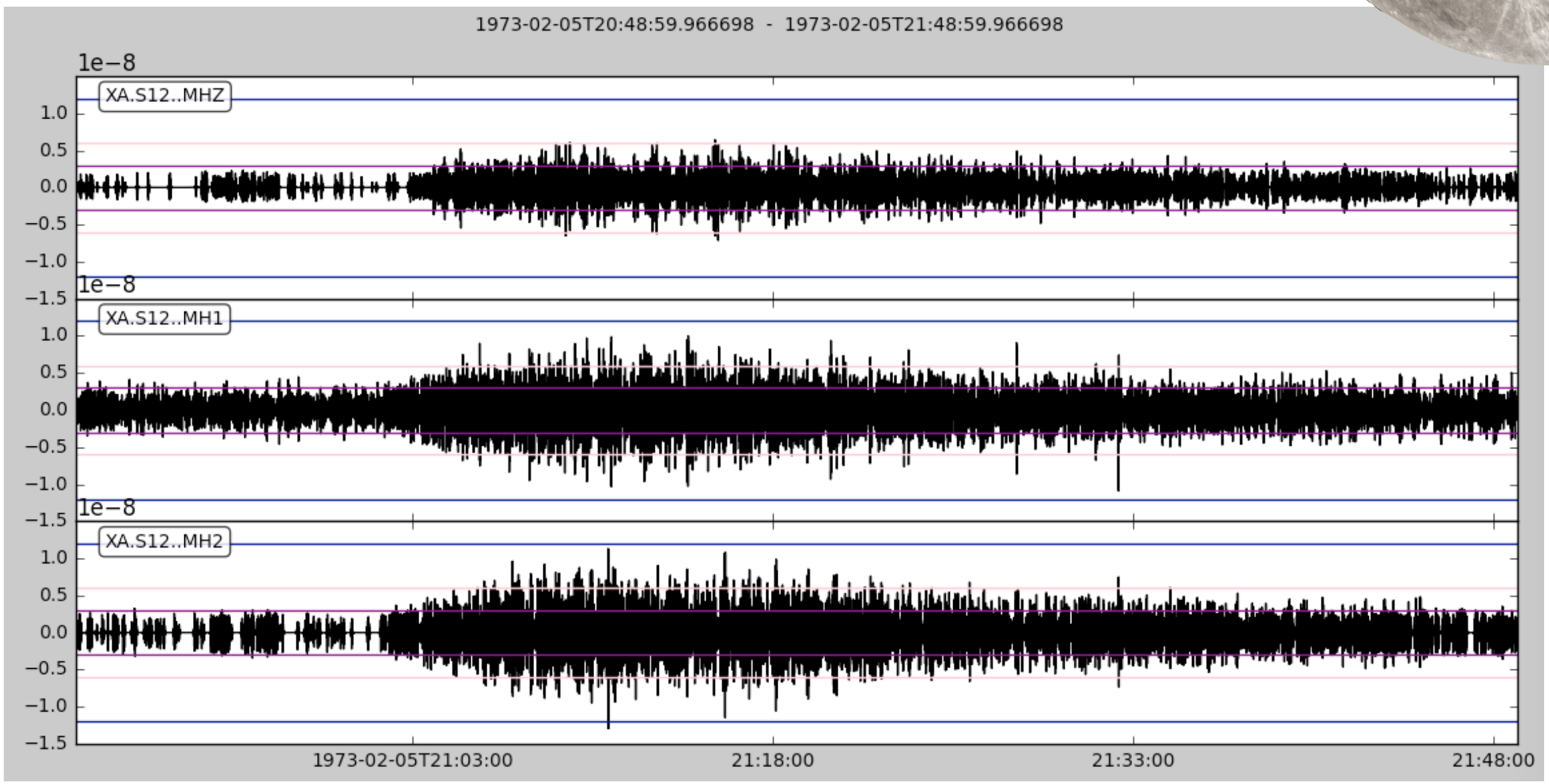
MEMS Seismometers



25 mm

Micro-Electro-Mechanical Systems (MEMS) sensors are small, lightweight sensors etched on a silicon wafer.

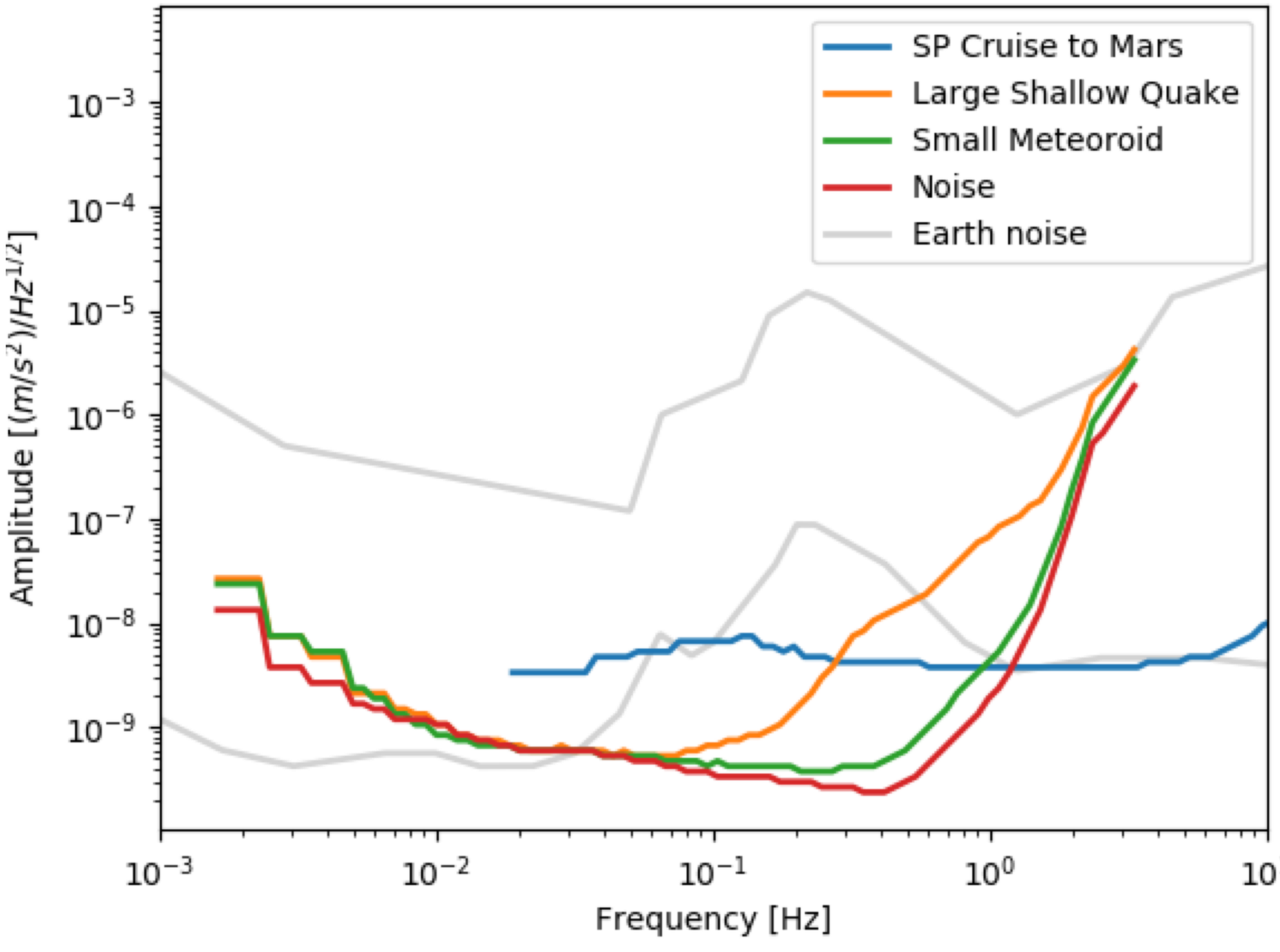
Lunar Seismograms
from Apollo



Meteoroid impact detected by Apollo 12's seismometer.

Over 13,000 observations detected in 6+ years of operation.

Performance

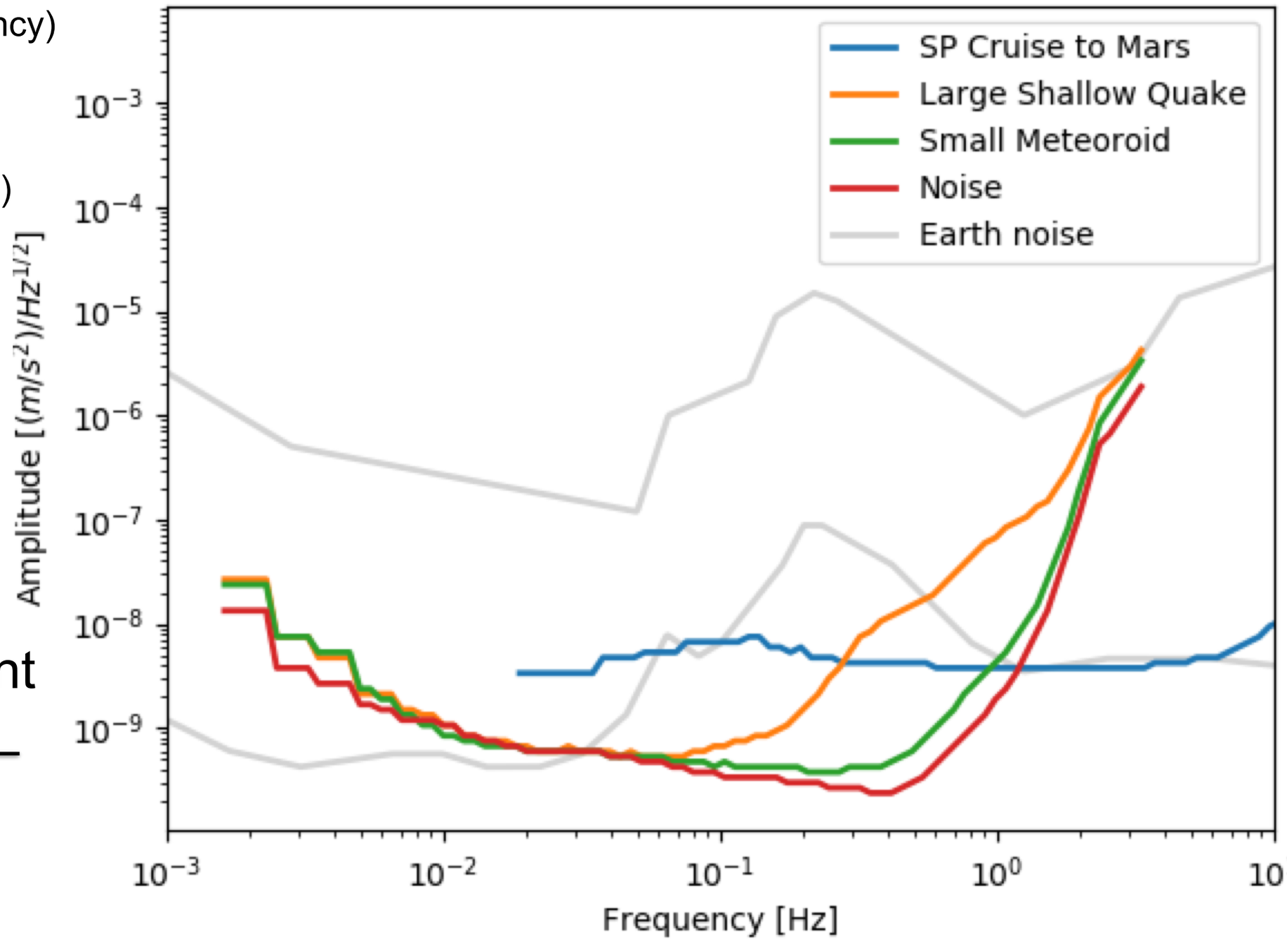


Performance

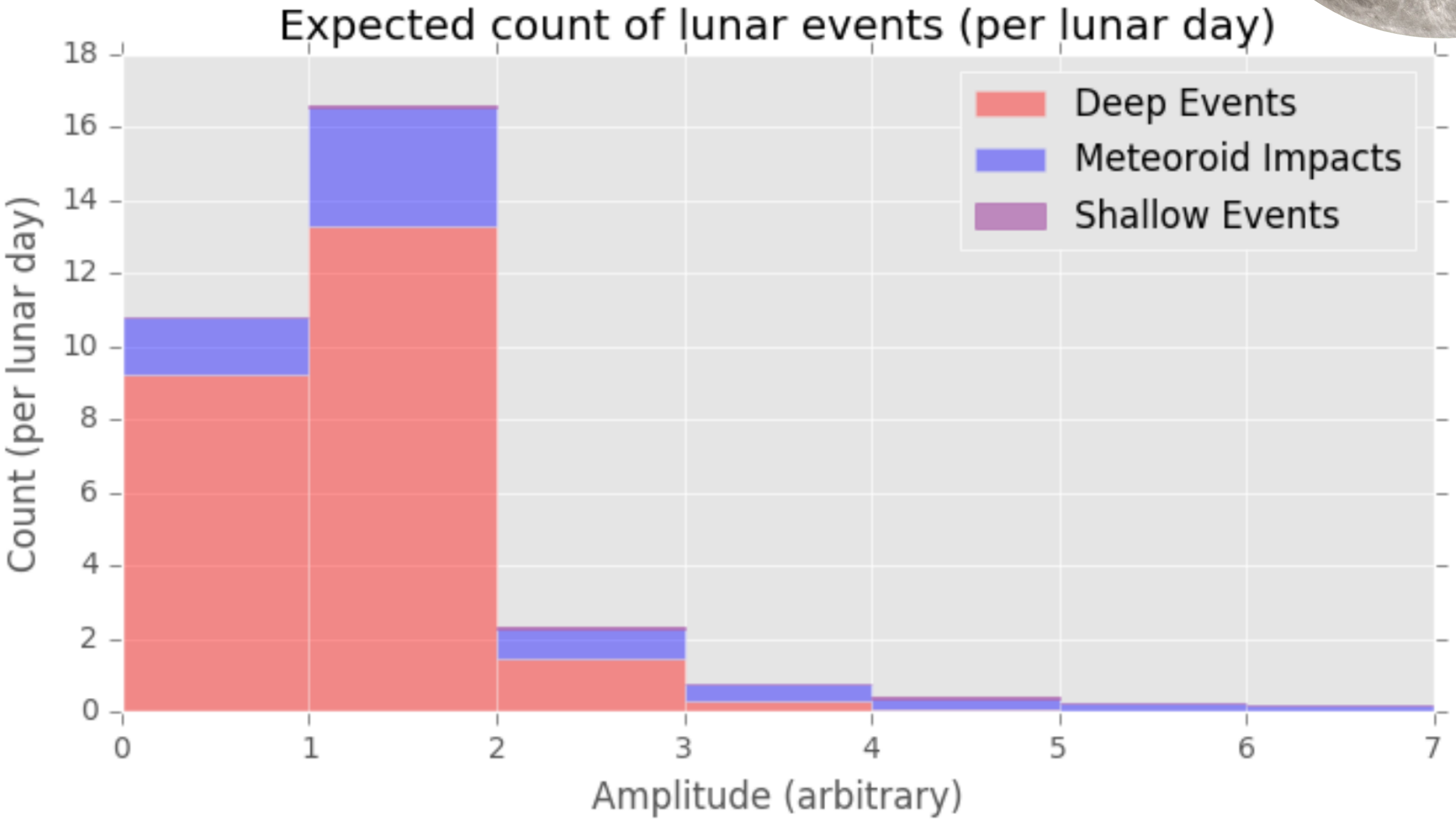
Impact on the Noise Floor

- Lower Gravity
  (reduce resonant frequency)
- Airless Body
  (thermal noise on spring)
- Airless Body
  (DT gain)
- Lower Radiation
  (lower noise pre-amp)
- Deck Deployment

- Digitisation
  (finer than Apollo)



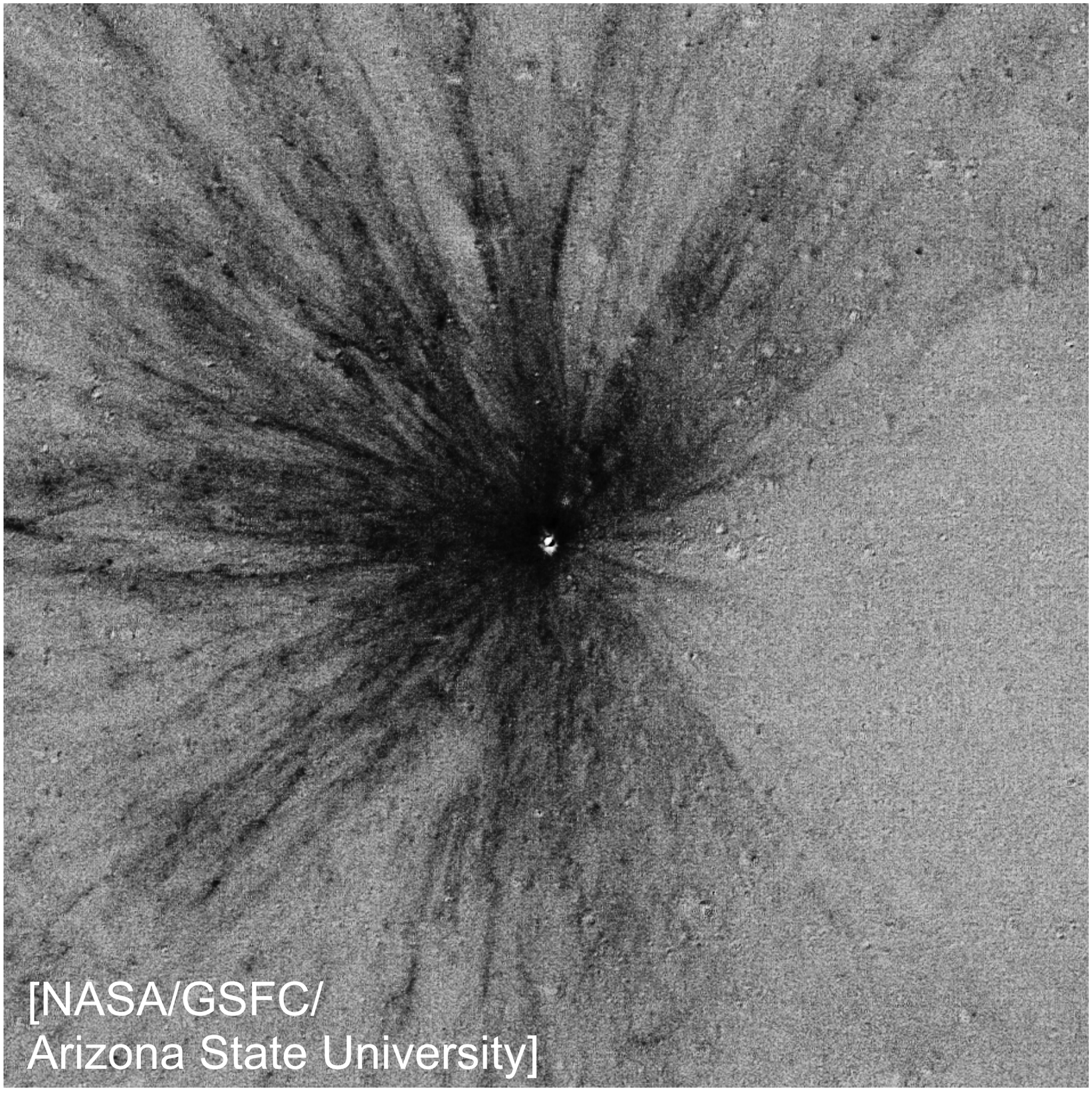
How many events?



Locating Events (today)

[Christian Fröschlin]

Locating Events (today)



12 m

1200 m

Conclusion

MEMS seismometers are feasible for lunar surface deployment.

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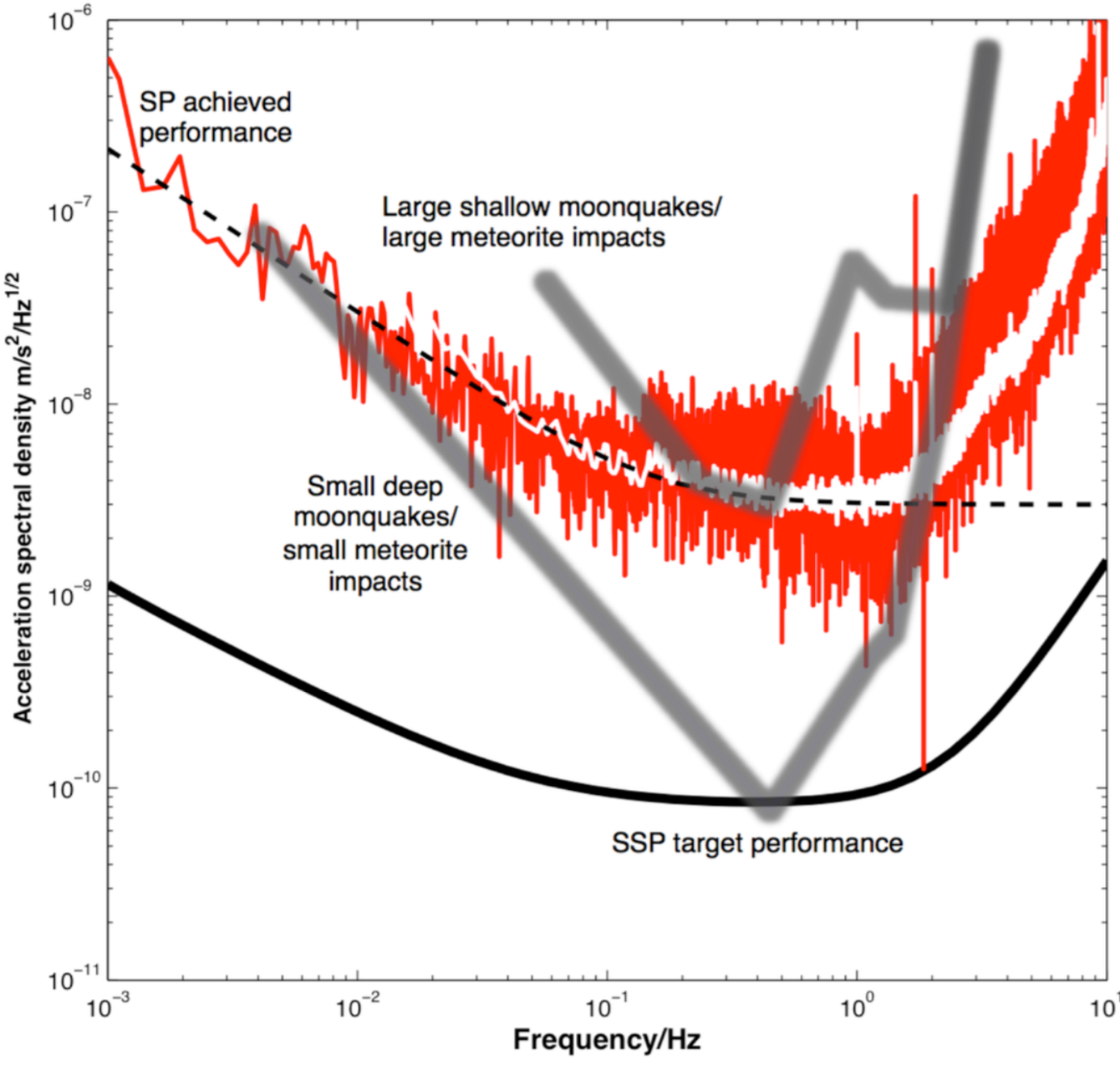
Photo Credits

Artist’s Impression, Lunar Lander, Astrobotic

Alan Bean deploys the ALSEP at Apollo 12, NASA
MEMS Seismometer, © Imperial College London
Moon, Eric Kilby, 2015
Lunar Eclipse, Christian Fröschlin, 2019 (https://eos.org/articles/a-meteor-struck-the-moon-during-the-total-lunar-eclipse)

Backup Slides

Performance



The measured spectral amplitude of the lunar seismic signals measured by Apollo compared to the performance of the InSight SP microseismometer, and the SSP target performance.

From Pike, W.T., et al., 2016. in 25 - European Lunar Symposium 2016.